Operational Risk Assessment for Airspace Planning
The SAM Methodology

Eurocontrol SAM

FUNCTIONAL HAZARD ASSESSMENT

PRELIMINARY SYSTEM SAFETY ASSESSMENT

SYSTEM SAFETY ASSESSMENT
Limitation of the FHA

Safety objectives

<table>
<thead>
<tr>
<th>Non RVSM approved aircraft not in RVSM airspace</th>
<th>Right encountering aircraft not in RVSM airspace</th>
<th>No other aircraft in horizontal overlap</th>
<th>Other aircraft in RVSM airspace</th>
<th>No vertical overlap with other aircraft</th>
<th>Consequence</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>v=315a-3 Page 3</td>
<td>Q=1.00a-1</td>
<td>Q=1.00a-3</td>
<td>Q=1.50a-4</td>
<td>Q=1.00a-3</td>
<td>ATC apply 200ft separation and clear aircraft out of RVSM airspace</td>
<td>3.10a-4</td>
</tr>
<tr>
<td>Success No H overlap</td>
<td>Null</td>
<td>Null</td>
<td>Null</td>
<td>Non RVSM approved aircraft passes through RVSM airspace uncloaked</td>
<td>3.51a-5</td>
<td></td>
</tr>
<tr>
<td>Failure Does not notify</td>
<td>Success No V overlap</td>
<td>Null</td>
<td>Null</td>
<td>Non RVSM approved aircraft passes through RVSM airspace uncloaked</td>
<td>3.50a-8</td>
<td></td>
</tr>
<tr>
<td>Failure No overlap</td>
<td>Failure H overlap</td>
<td>Failure V overlap</td>
<td>Failure Non-approved</td>
<td>Two aircraft in conflict (SG1)</td>
<td>3.51a-11</td>
<td></td>
</tr>
<tr>
<td>Failure H overlap</td>
<td>Null</td>
<td>Failure V overlap</td>
<td>Two aircraft in conflict (SG1)</td>
<td>5.29a-12</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure A.4: Hazard #5 - Risk Analysis

Context Dependant?
Context associated to an operational hazard

- Crossing angle
- Climbing rate
- Vertical separation
- .....
Limitation of the SSA

Do reported incidents account for all «intermediate» errors?
Example of undetected operational error
Part II

A methodology for operational risk assessment with radar surveillance
The concept of “assigned route” (with navigation error from this assigned route) is difficult to apply in continental airspace.
Specificity of radar surveillance (II)

- Descent
- Climb

The “straight line” assumption does not always hold
(e.g. in TMA)
Specificity of radar surveillance (III)

For horizontal manoeuvres, it is necessary to process flight plan in order to interprete the operational context.
Analytical model
Modeling of operational errors

**operational error:** any situation where the controller’s representation of the future trajectory of an aircraft does not correspond to the reality

horizontal  
vertical
The “risk exposure” concept

Risk exposure associated to a scenario of operational error:
-risk under the assumption that **whenever aircraft can fall into this scenario, they do.**
The “risk exposure” is time oriented

\[ \Delta t_p \]

\[ \Delta t_c \]
Modeling of controller’s intervention

**hazard rate**

\[
\lambda(t) = \lim_{dt \to 0} \frac{\Pr\{t + dt > T \geq t | T \geq t\}}{dt}
\]

A conservative modelling for the detection delay is a constant hazard rate.

Beginning of operational error  Detection by the controller  Collision
Properties of the risk exposure concept

The risk exposure:

- Is estimated from radar archive data
- Returns all pairs likely to fall under an operational scenario
- Associate to all pairs a probability of incident/accident
Applications
Edition of encounters (I)

- Current conflict parameters
- Horizontal view
- Displayed fields
- Conflict fields to display
- Time slider
- Current flight parameters
- Vertical view
- Current aircraft positions
Edition of encounters (II)

Vertical scenario

Horizontal scenario

First aircraft stops climbing

Horizontal intersection in case of operational error

Vertical overlap

Horizontal crossing point in the case of "straight line"

Horizontal view

Vertical view
Identification of operational risk

Descent
Climb
Vertical encounters
Horizontal encounters
Risk estimation

Yearly reported incidents + Yearly incidents (Risk Exposure) → How often an encounter results in an operational error?

Probability of accident for encounters + 

Risk estimate